The Dreamcatcher: Interactive Storytelling of Dreams

Edyta Paulina Bogucka
Technical University of Munich (DE)

Bon Adriel Aseniero
Autodesk Research, Toronto (CA)

Luca Maria Aiello
IT University of Copenhagen (DK)

Daniele Quercia
Nokia Bell Labs, Cambridge (UK) and CUSP King's College London (UK)

***Abstract*—Sleep scientists have extensively validated the *continuity hypothesis*, according to which our dreams reflect what happens during our waking life. Yet, only a few attempts have been made to increase the general public's awareness about the benefits of dream analysis in better understanding and improving our daily life. We designed "The Dreamcatcher", an interactive visual tool that explores the link between dreams and waking life through a collection of dream reports. We conducted a user study with 154 participants and found a 25% increase in the number of people believing that dream analysis can improve our daily lives after interacting with our tool. The visualization informed people about the potential of the continuity hypothesis to a surprising extent, to the point that it increased their concerns about sharing their own dream reports, thus opening new questions on how to design privacy-aware tools for dream collection.**

1. Introduction

The idea that dreams might contain hidden messages that can influence our waking life has fascinated humankind since the beginning of civilization. During the second century AD, Artemidorus Daldianus produced a five-volume treatise entitled "Oneirocritica" ("The Interpretation of Dreams"), in which he associated symbolic meanings to images and situations that frequently appeared in dreams [1]. Since then, sleep scientists have found abundant evidence about the connection between daily experiences and dreaming, which is summarized by the so-called *continuity hypothesis:* most dreams are a *continuation* of what we experience during the day [2]. This hypothesis provides a theoretical basis for therapy as it can be used to raise self-awareness, identify latent emotional states, and to help people cope with significant life events [3].

Despite the continuity hypothesis being wellstudied, little effort has been spent to communicate its importance to the general public. At one end of the spectrum of dream-related research, there are projects focused on the analysis of dream reports that rely on scales and inventories developed by psychologists [4]. At the other end, there are visual representations of the content of dreams that are mostly artistic [5], [6]. To fill this gap between these two extremes, we tackle the challenge of conveying different aspects of the continuity hypothesis in a visual form that is informative, yet appealing to a non-expert audience. We did so by building a visual interface for dream storytelling that uses the visual metaphor of a familiar cultural artifact: the *Dreamcatcher* (publicly available at https://social-dynamics.net/dreams). The visualization allows people to explore the waking-life and dreams of seven dreamers. To achieve that, we tapped into data from Dreambank, a public source of dream reports, and we built upon a recently-developed algorithmic tool [7] that uses Natural Language Processing (NLP) to produce an automatic analysis of dreams according to the *Hall-Van de Castle* inventory [4], a validated and widely-used dream coding scale. We demonstrated the effectiveness of our visualization in conveying the implications of the continuity hypothesis in daily life through a user study involving 154 Amazon Mechanical Turk crowdworkers.

(BEGIN SIDEBAR)

2. Related work

Most dream-related visualizations rely on standard charts and word clouds and are embedded in personalized dream logging apps used predominantly to record dreams, tag them, and share them with others. A few original dream-related visualizations have been proposed in the last years, one "scrolly-telling" exploration of dream-related Google searches [8] and one which attempts to map the imaginary space of dreams with traditional cartography tools [5]. The lack of a standard visualization paradigm for dream exploration opens the possibility to create visual forms that are less constrained by standard genres. For example, *visaphors* borrow features from one domain to highlight crucial aspects and communicate key take-away messages in another domain [9]. Reshaping established forms to a new style and for novel purposes proved effective in evoking surprise, stimulating curiosity, and persuading the audience [10]. The nature of dream reports lends itself to this type of visualization, as dreams anticipate retrospection, interpretation and remembrance. (END SIDEBAR)

3. Methods

3.1. Dream data and coding system

Our tool visualizes a curated collection of dreams from DreamBank, an online repository containing over 38,000 dream reports gathered from past research on dreams [11]. Dreams are annotated with their dates of recording, which span six decades (from 1960 to 2015). Sets of dream reports are linked to free-text descriptions of the dreamers, which contain information about their gender, age (ranging from 7 to 74), profession, and personal history.

In addition to the text and metadata available in the database, we enriched the visualization with analytics from the Hall-Van de Castle's dream coding system [12], a standard reference for the quantitative study of dreams. The Hall-Van de Castle system consists of numerical scales partitioned into ten categories; the dream analyst parses the report to count instances of elements belonging to those categories and uses simple formulas to combine those counts to produce a dream profile. In practice, these categories are not of equal importance in capturing the psychopathological value of the dream's content. Dream scientists determined that the three categories of *characters*, social *interactions*, and *emotions* (and their subcategories) are the most informative ones [13]. In this work, we focused on these three categories.

Characters. People, animals, and imaginary figures who appear in the dream report. We measured the fraction of characters who are: male and those who are female (*Male% and Female%*); family members of the dreamer (*Family%*); animals (*Animals%*); either fictional or dead (*Imaginary%*).

Interactions. Interactions among characters of two types: friendly and aggressive. We measured the number of friendly interactions (*Friends*) and the number aggressive interactions (*Aggression*), both divided by the total number of characters.

Emotions. Markers of positive or negative emotions in the dream report. In particular, we measured the ratio between the number of negative emotions and the total number of emotions expressed in the dream (*Negative emotions%*).

To spot anomalies in the content of a dream, one needs to compare the numerical proportions defined above against the values of a "typical" dream report. Dream researchers previously estimated such normative proportions [4]. Given a measured proportion p and the corresponding normative proportion p_{norm}, we compared them using Cohen's h, a measure of distance between two proportions:

$$h = (2 \cdot arcsin(\sqrt{p})) - (2 \cdot arcsin(\sqrt{p_{norm}})). \tag{1}$$

3.2. Automatic Dream Coding

Traditionally, dream coding is performed manually, which is time consuming. To quickly score large collections of reports, in previous work we developed a simple Natural Language Processing (NLP) tool to extract the elements of the short version of the Hall-Van de Castle scale from text [7]. We assessed the accuracy of our NLP tool using a set of dream reports from Dreambank which have been hand-coded by dream experts. Using a linear combination of the negative emotion score and the aggressive interaction score returned by the tool, we extracted a *dream unhealthiness score*, normalized in a range between 0 (positive dream) and 1 (nightmare). We used this measure to differentiate the visual representation of good and bad dreams.

4. The Dreamcatcher Design

4.1. Modes of persuasion

The design choices of the Dreamcatcher were motivated by the three modes of persuasion of the Aristotelian rhetoric: *logos* (persuasion through reasoning and facts); *ethos* (speaker's credibility); and *pathos* (evoking feelings and emotions).

Logos: Coding and Keywords. To convey the practical and logical implications of the continuity hypothesis—that dreams reflect real life—we presented dreams in relation to the analytical dimensions of the Hall-Van de Castle scale. We showed eight dimensions for each dream: the ratio of the number of family members, imaginary beings, female characters, male characters, friends, and animals among all characters, the percentage of aggressive interactions, and the amount of negative emotions. We used the unhealthiness scores to divide dreams into four groups: nightmares, unpleasant, neutral and sweet dreams.

Ethos: Effective Personas. We introduced the real-life story of the dreamers to make appear their dream reports more trustworthy and relatable. Existing research in dream analysis suggests that the continuity hypothesis is mostly predominant for certain persona archetypes: (1) special populations with negative waking life experiences, such as mute-deaf, blind, or traumatized people (2) individuals with clearly distinguishable aspects of waking life, dreaming life and biographical links between them [3]. Following these principles, we selected seven personas, including both individuals and groups, which represent a wide spectrum of negative, normative and positive examples of the continuity hypothesis during different life stages (Table 1).

Pathos: A visual metaphor. The process of building a visaphor involves transferring selected characteristics from the source domain to the data visualization domain [9]. We drew inspiration from the appearance of the dreamcatcher, an artifact originating at the Native American Ojibwe tribe that is believed to capture dreams and filter the bad ones out [14]. Our *Dreamcatcher* is the digital interpretation of such artifact. Our visaphor builds on the analogy between physical and digital: as the traditional artifact captures dreams, our digital version automatically captures and codes their meanings from data.

4.2. Interaction tasks

The Dreamcatcher allows for four main tasks:

T1 **Select personas of interest**. The user can investigate the history of different personas and check simple hypotheses on the relationship between their waking life and their dreams. The broad selection of personas encourages the user to empathize with at least some of them and become more positive about the

Persona type	Persona name	Characteristics	Aspect of the hypothesis	#Dreams
Characteristic life	Horseplayer	Middle-aged married man, factory worker and animal lover. He plays the horses and notes down his dreams to predict the winner.	Interests and passions	129
	Izzy	Teenage girl passionate about collecting her dreams, a normative set of waking life experiences	Daily concerns and activities.	123
	Female artist	An artist in late 30s working on paintings, photographs and films.	Daily activities and experiences	118
	Cross-dressing businessman	Wall Street businessman in his 50s, married, father with interests in cross-dressing.	Self-awareness	118
	Future brides	College women's dreams that involve weddings.	Life events	54
Special groups	Blind dreamers	People affected by complete vision loss either from birth or for over 20 years	Senses and fantasies.	121
	War veteran	Vietnam war veteran who had a very intense and traumatic experience of the conflict.	Psychological issues	114

Table 1: The personas in the Dreamcatcher.

interpretation of their own dreams.

T2 **Filter dreams by category**. The user can get a summary of the good or bad oneiric experiences of a selected persona.

T3 **Select individual dreams**. The user can review the dream's dimensions produced by the automated Hall-Van De Castle's coding tool.

T4 **Read dream reports and associated keywords**. The user can investigate the connection between real life and waking life through a subset of representative dreams. The similarity between the persona's dreams to those that the user might have had could contribute to trigger empathetic responses.

4.3. Interface design

Visual Elements The main component of the visualization mimics the two parts of a traditional dreamcatcher artifact. These two parts are interactive and inter-dependent.

The lower part contains feathers hanging on strings (Figure 1). Each feather represent a single dream report and their arrangement is chronological, the leftmost feathers showing the oldest dreams. The feathers are encoded using a colorblind-friendly diverging color scheme with four classes. Their colors are based on the corresponding reports' unhealthiness scores and range from red (nightmare) to blue (sweet dream). Additionally, we enlarged and outlined a few selected feathers to draw user's attention; when clicked, these special feathers display their representative dream reports along with a short explanation on which aspect of the continuity hypothesis is valid for this persona. The connection between dreams and real life was emphasized by highlighting the keywords in a report that reflected the dreamer's real-life circumstances [15].

The upper part of the Dreamcatcher contains a radar chart encoding the dimensions of the Hall-van de Castle scale of the selected dream report (Figure 2). Hovering on the large beads in the hoop provides the definition of each dream dimension. The radar chart takes different forms depending on the selected persona. For instance, the shapes associated with future brides or a schoolgirl recall heart motifs, while the shape associated with a war veteran has sharp edges (Figure 4).

Visual Narrative We aimed at capturing the user focus towards the center of the interface by using a dark, radial gradient color background. The introduction of the different aspects of the continuity hypothesis unfolds frame by frame (Figure 3), allowing the user to incrementally explore the dream reports:

Frame 1: The Welcome Screen. The initial screen shows only a rhetorical question *"What can we learn from automatically interpreting thousands of dreams?"*, and a start exploration button.

Frame 2: Revealing the Personas. A screen with

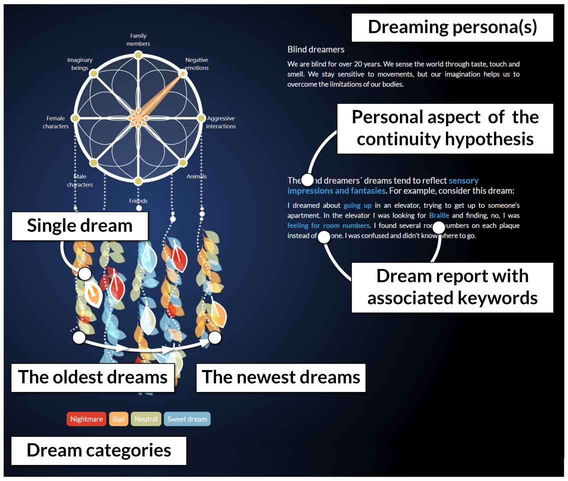


Figure 1: Each feather is a dream report and is color-coded depending on the dream's unhealthiness score. If a feather's report is made available, then the feather is shown with a white bold line.

a sentence explaining the continuity hypothesis in plain English, and a list of personas to choose from.

Frame 3: The Dreamcatcher. When a person is selected, the Dreamcatcher appears at the center of the screen. The right part of the interface provides a short biography of that persona. Every time the user switches to a new persona, the Dreamcatcher's appearance changes. For instance, the feathers are rotated randomly to give a sense of movement and encourage serendipitous exploration. By using the buttons in the legend the user can switch on and off respective dream categories to filter the data and avoid visual clutter.

Frame 4: Details-on-Demand. Clicking on a single feather displays the dream dimensions in the radar chart. By clicking on the enlarged feather, the user is shown the dream report with highlighted keywords on the right panel. By comparing the colors of the catchers of different personas, the user can assess the differences in their dream patterns (Figure 4). For example, the war veteran had many nightmares and his catcher's feathers are red, while the the teenage girl's catcher has a variety of colors, reflecting a good balance among all the dream categories.

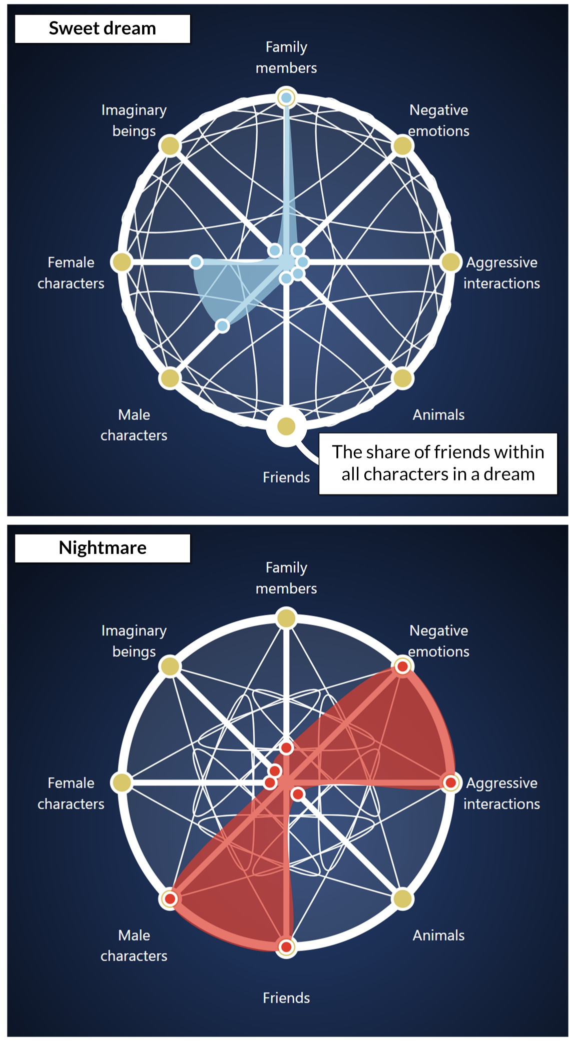


Figure 2: The radar charts showing how a dream report scores on the Hall-Van de Castle's scale.

5. Evaluation

The goal of our user study was to test whether the Dreamcatcher could further awareness of the continuity hypothesis among the general public. To this end, we measured the extent to which our study participants changed their minds about the continuity hypothesis after interacting with the Dreamcatcher.

5.1. Experimental Setup

We recruited 154 participants from the Amazon Mechanical Turk (AMT) platform and guided them through an experiment in 6 parts.

Part 1: Pre-study questionnaire. The participants were asked to rate three statements on a 5-point Likert scale: *i) "Recalling and interpreting*

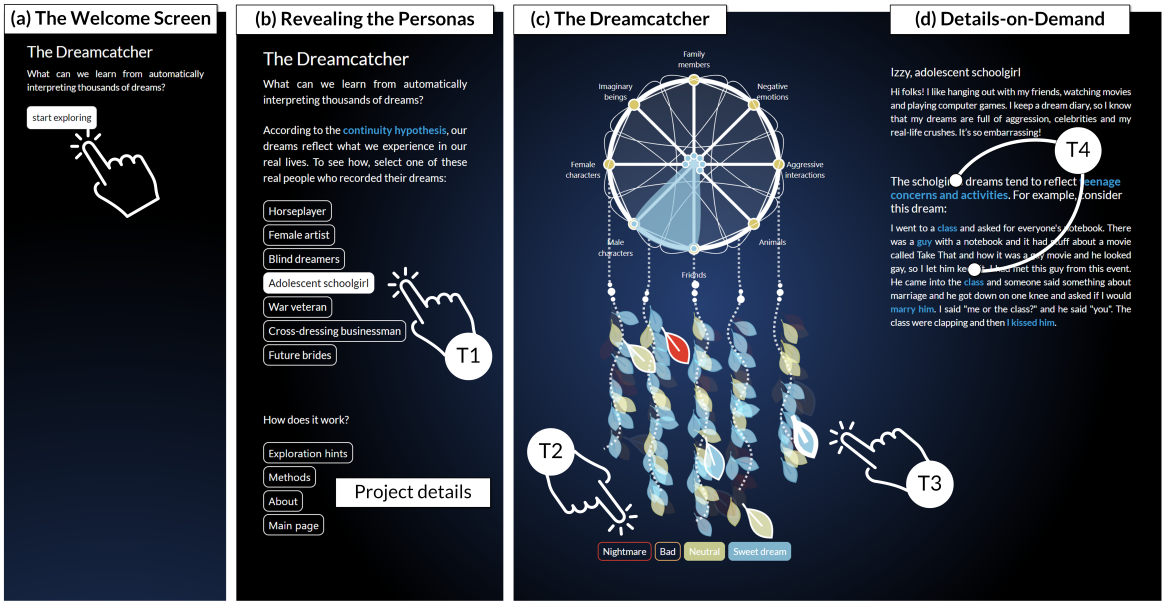
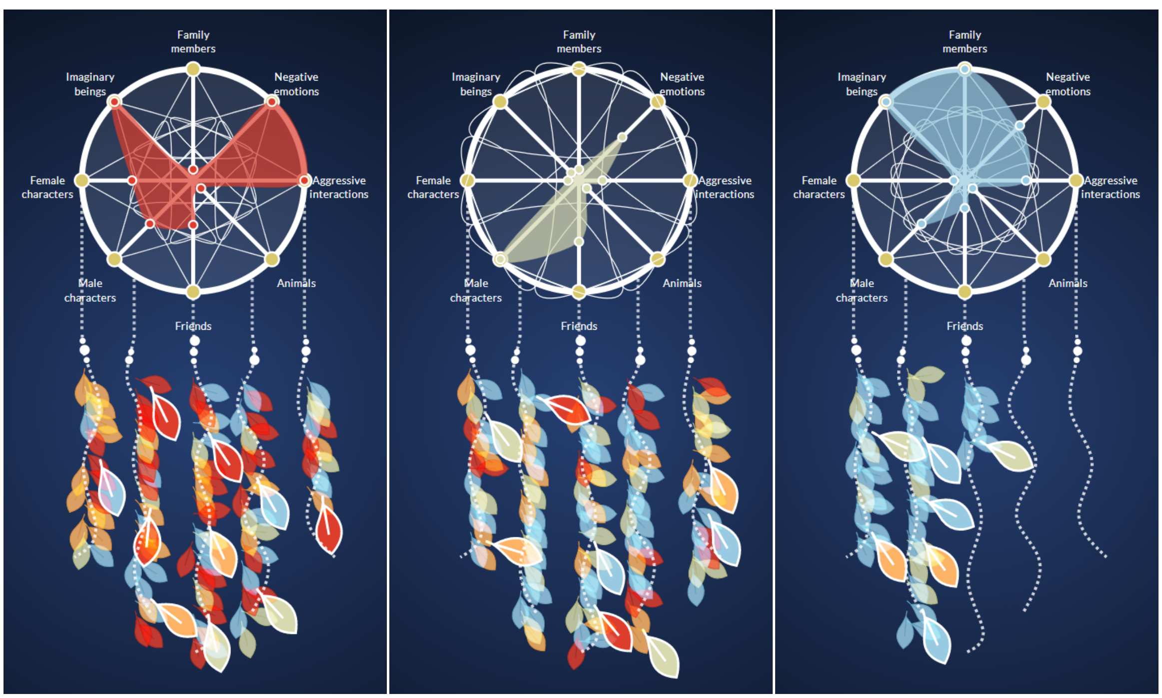


Figure 3: The four frames and interaction tasks in our visualization: (a) the welcome screen, (b) the panel for selecting a persona (T1), (c) the appearance of the Dreamcatcher while filtering dreams by category (T2), and (d) retrieving details on a dream report (T3, T4). User advances the visual narrative through responsive interface elements marked with the click icon. Video available: http://social-dynamics.net/dreams/teaser.mp4.



(a) The war veteran (b) The teenage girl (c) Future brides

Figure 4: The Dreamcatchers of three personas show (a) negative, (b) normative and (c) positive examples of dreaming patterns.

dream patterns improves real life."; *ii) "Having people share their dreams encourages me to interpret my own."*; and *iii) "I am willing to share my dreams for scientific purposes."*

Part 2: Experimental conditions. We split the participants equally between two experimental conditions: a treatment condition in which they were shown the Dreamcatcher visualization, and a control condition in which they were shown the *Control Visualization*: a simple text-based visualization that mimics the ways dreams databases on the Web currently present dream reports.

Part 3: Exploration. The participants were invited to explore the interface by going through the stories and dreams of all the different personas.

Part 4: Test question. After completing the exploration, the participants were asked to answer a "test question" that ascertains whether they paid genuine attention to the task.

Part 5: Post-study questionnaire. The participants were asked again to rate the three statements of the pre-study questionnaire (part 1).

Part 6: Open feedback. The participant were asked to answer shortly to a few open questions concerning interface usability and overall experience.

To ease the interpretation of the results, for each question the questionnaire independently, we segmented our participants based on their response into three different segments, as done in a previous work [16]:

- **Negatively Inclined (NI)**: Participants who rated a statement as "not at all" or "not that much."
- **Neutral/Weakly Inclined (NWI)**: Participants who rated the statement as "partly."
- **Positively Inclined (PI)**: Participants who rated the statement as "somewhat" and "totally."

To quantify opinion shifts after the use of the interfaces, we measured the *percentage growth rate* of each segment as a consequence of receiving a given treatment:

$$\Delta NI = NI_{after} - NI_{before},$$

where NI_{after} is the percentage of participants who were negatively inclined towards a statement *after* experiencing the visualization, and NI_{before} is the percentage of participants who were negatively inclined towards the same statement *before* experiencing the visualization. In a similar way, we computed the two remaining percentage growth rates:

$$\Delta NWI = NWI_{after} - NWI_{before},$$

$$\Delta PI = PI_{after} - PI_{before}.$$

We also calculated the *mean attitude change* per statement, which is the mean of differences between the self-reported attitude of all users after and before the seeing the visualization.

5.2. Results

Before the visualization In both conditions, before experiencing any visualization, 51% agreed that dream analysis could improve their real lives, 58% were willing to have their own dreams interpreted, and 82% were willing to share their dreams for research purposes (Table 2).

Statement	NI	NWI	PI
S1 improves real life	26%	23%	51%
S2 willing to interpret	19%	23%	58%
S3 willing to share	9%	9%	82%

Table 2: Percentage of participants in the three segments (negatively/neutrally/positively inclined towards each statement) *before* being exposed to any visualization.

After the visualization After experiencing any of the two visualizations, our participants changed their minds about S1 ("dream analysis improves real life"). The "positively inclined" segment grew by 25% among those being exposed to the Dreamcatcher, and by 20% among those being exposed to the Control Visualization (Table 3). More interestingly, for both S2 ("willingness to interpret") and S3 ("willingness to share"), our participants did change their mind, but not in the way we expected: instead of being more willing to interpret or share their own dream reports after experiencing the visualizations, they were less inclined to do so, and all the more so when exposed to the Dreamcatcher. This puzzling results was later explained with the qualitative feedback we collected.

Statement	Treatment	ΔNI	ΔNWI	ΔPI
S1 "improve"	Dreamcatcher	-15 %	- 10%	**25%**
	Control	-17 %	- 3%	20%
S2 "interpret"	Dreamcatcher	13 %	-3%	-10%
	Control	1 %	5%	-6%
S3 "share"	Dreamcatcher	5%	1%	-6%
	Control	0%	5%	-5%

Table 3: Percentage growth rates for the three segments (negatively/neutrally/positively inclined towards each statement) after our participants are exposed to either the Dreamcatcher or the Control Visualization.

Table 4 shows the mean attitude change by statement across Dreamcatcher and Control Visualization. The highest mean attitude change for both treatments was observed in S1 ("dream analysis improves real life"). For S2 ("willingness to interpret"), the negative inclination is higher with Dreamcatcher than for Control. The trend is opposite for S3 ("willingness to share").

Treatment	Statistics	S1	S2	S3
Dreamcatcher	mean change	0.494	-0.260	-0.156
	p-value	**0.000**	**0.073**	0.149
Control	mean change	0.359	-0.115	-0.218
	p-value	**0.002**	0.394	**0.028**

Table 4: Mean attitude change of participants by statement.

Free-form feedback After experiencing the Dreamcatcher, some participants took a firm stand against dream interpretation. One participant said: *"Not really into dream interpretation. Sometimes things are just best kept unknown."*. Two others added: *"I do question what else they take into account to get to know me and my personality before analyzing my dreams,"*; and *"The people's lifestyle being in line with dreams is shocking."*. These comments suggest that the Dreamcatcher made visible not only the power of dream interpretation but also its corresponding privacy concerns. They also explain why 10% switch from being positively inclined towards sharing their dream reports (S2 and S3) to be either neutrally or negatively inclined towards it. The control group mentioned the data privacy issues more often than the Dreamcatcher group. Users who performed the tasks on the website argued the that the text-based interface seem to be too simple and they would like to see *"more illustrative and colorful examples"* and *"more stories to learn from"*.

As for statement S1 ("dream analysis improves real life"), participants tended to be more favorable after being exposed to the Dreamcatcher, and that was reflected in their qualitative feedback. Indeed, to describe the Dreamcatcher, they used words like *interesting, original, unique, beautiful, pretty, lovely, cool, enjoyable,* and *engaging*. They also found the Dreamcatcher easy to use (*"The Dreamcatcher was not intuitive at first, but eventually became straightforward enough to figure out"*); found its dream categorization useful (*"The different colored leaves is an excellent idea"*); and found its use of personas appealing (*"I like the idea and would probably browse through an entire catalog of people that choose to put their dreams up this way"*, and *"The part that I liked best was just reading the descriptions that the subjects offered of their dreams"*).

6. Conclusion

The Dreamcatcher offers a new way of visualizing salient aspects associated with dream reports, fostering a deeper understanding of the continuity hypothesis among the general public. Our Dreamcatcher can inform new solutions for personalized applications for dream pattern analysis. The shape of the tool makes it easy to compare the quality of dreams, yet makes it in a privacy-aware way. At first glance, Dreamcatcher looks like a wallpaper or an artistic graphic. The visualization is therefore incomprehensive to external viewers, yet understandable and meaningful for the user. In a scenario in which users are allowed to create and share their own personalized Dreamcatcher with others, the form of the tool has the potential to evoke discussions about sleep patterns and raise awareness on their connections to well-being. Indeed, after interacting with the Dreamcatcher, 25% of our study participants changed their minds, finding that dream analysis could indeed improve the understanding of their waking lives. As one expects, the ability of extracting powerful real-life markers from dream reports inevitably results in privacy concerns. As such, one main area of future research is whether it is possible to analyze and visualize dreams in a privacy-preserving way. Our results suggest that it is possible to build technologies that bridge the current gap between real life and dreaming, ultimately making our 'sleeping mind' quantifiable.

REFERENCES

1. A. Daldianus, N. Rigault, J. J. Reiske, and J. G. Reiff, *Oneirocritica*, vol. 2. Palala Press, 2015.
2. P. McNamara, "The Continuity Hypothesis of Dreams: A more balanced account." https://www.psychologytoday.com/us/blog/dream-catcher/201409/the-continuity-hypothesis-dreams-more-balanced-account, September 2014. [Online; accessed March 2021].
3. M. Schredl, "Continuity in studying the continuity hypothesis of dreaming is needed," *International Journal of Dream Research*, vol. 5, no. 1, 2012.
4. G. W. Domhoff, *Finding Meaning in Dreams. A Quantitative Approach*. New York: Springer, 1996.
5. C. M. I. Enescu and L. Hurni, "Fictional Volunteered Geographic Information in Dream Cartography," *International Journal of Cartography*, vol. 3, no. 1, 2017.
6. M. Blagrove and J. Lockheart, "Gallery of Dreams and Artworks." https://dreamsid.com/gallery-of-dreams-and-artworks.html, 2019. [Online; accessed March 2021].
7. A. Fogli, L. M. Aiello, and D. Quercia, "Our dreams, our selves: automatic analysis of dream reports," *Royal Society Open Science*, vol. 7, no. 8, 2020.
8. F. Fragapane, "The Shape of Dreams. A visual exploration of Google searches for the interpretation of dreams." https://the-shape-of-dreams.com, January 2020. [Online; accessed March 2021].
9. D. J. Cox, "Metaphoric Mappings: the Art of Visualization," in *Aesthetic Computing* (P. A. Fishwick, ed.), ch. 6, pp. 89–114, Cambridge, Massachusetts: The MIT Press, 2006.
10. F. B. Viégas and M. Wattenberg, "Artistic Data Visualization: Beyond Visual Analytics," in *Online Communities and Social Computing* (D. Schuler, ed.), (Berlin, Heidelberg), pp. 182–191, Springer, 2007.
11. A. Schneider and G. W. Domhoff, "The DreamBank." http://dreambank.net/, 2020. [Online; accessed March 2020].
12. C. S. Hall and R. L. Van de Castle, *The Content Analysis of Dreams*. New York: Appleton-Century-Crofts, 1966.
13. W. Domhoff, *The Scientific Study of Dreams: Neural Networks, Cognitive Development, and Content Analysis*. American Psychological Association (APA), 2003.
14. K. Harris, "The Legend of The Dream Catcher." https://historydaily.org/the-legend-of-the-dream-catcher, 2019. [Online; accessed March 2021].
15. T. L. DeCicco, "What is the story telling? Examining discovery with the storytelling method (TSM) and testing with a control group," *Dreaming*, vol. 17, no. 4, pp. 227–238, 2007.
16. A. V. Pandey, A. Manivannan, O. Nov, M. Satterthwaite, and E. Bertini, "The persuasive power of data visualization," *IEEE Transactions on Visualization and Computer Graphics*, vol. 20, no. 12, pp. 2211–2220, 2014.

Edyta Paulina Bogucka was a data visualization intern at Nokia Bell Labs and is currently a Doctoral Candidate at the Technical University of Munich. Contact her at e.p.bogucka@tum.de.

Bon Adriel Aseniero was a data visualization intern at Nokia Bell Labs and is currently a Senior Research Scientist at Autodesk Research. Contact him at bon.aseniero@autodesk.com.

Luca Maria Aiello is an Associate Professor at the IT University of Copenhagen. Contact him at lajello@gmail.com.

Daniele Quercia is the Department Head at Nokia Bell Labs in Cambridge (UK) and Professor of Urban Informatics at Kings College London. Contact him at quercia@cantab.net.